National Science Foundation [NSF] International Materials Institutes [IMI]

Advanced Neutron Scattering NetWork for Education and Research [ANSWER]:

With a Focus on Mechanical Behavior of Materials

P. K. Liaw[1], H. Choo[1], R. A. Buchanan[1],

C. Hubbard[2], and X. L. Wang[2]

1.Department of Materials Science and Engineering

University of Tennessee

Knoxville, TN 37996-2200

2. Oak Ridge National Laboratory

Knoxville, TN 37831-6376

Acknowledgement

- *We are very grateful to Dr. Carmen Huber and Dr. Tom Weber of the National Science Foundation for the support (DMR-0231320).*

- *We would like to thank Ms. Lan Huang for her most kind help in preparing the slides.*

PROJECT OVERVIEW

CONFIRMED PARTICIPANTS

- 8 Countries from 3 Continents
- 25 Faculty Members from 16 Universities
- 11 Scientists from 7 Neutron Facilities
- 9 Researchers from 8 Industries

SERVICE PROGRAM

- Exchange Program
- International Collaboration
- Workshop and Symposium
- Internet Resources
- Partnership Development
- Internships

NSF-IMI ANSWER

EDUCATION PROGRAM

- New Faculty Position Openings
- Graduate Fellowships
- New Courses on Neutron Scattering
- Outreach Program

RESEARCH PROGRAM

- In-Situ Studies of Mechanical Behavior
- Real-time Measurements of Internal Stresses
- In-Situ Characterization of Microstructures
- Theoretical Modeling

List of Confirmed US and International Participants

<FACULTY PARTICIPANTS>

US

[1] Dr. Charlie R. Brooks, Professor, Materials Science and Eng. [MSE], Univ. of Tennessee [UT].

[2] Dr. Raymond A. Buchanan, Robert M. Condra Professor, MSE, UT.

[3] Dr. Hahn Choo [Co-Director], Assistant Professor, MSE, UT.

[4] Dr. Bjorn Clausen, Senior Researcher, Materials Science, California Institute of Technology.

[5] Dr. David C. Dunand, Associate Professor, MSE, Northwestern Univ. [NU].

[6] Dr. Takeshi Egami, Distinguished Professor, MSE, UT/Univ. of Pennsylvania [UP].

[7] Dr. Aaron Krawitz, Professor, Mechanical & Aerospace Eng., U. of Missouri, Columbia [UMC].

[8] Dr. Peter K. Liaw [Director], Professor, Ivan Racheff Chair of Excellence, MSE, UT.

[9] Dr. Philip Nash, Professor, Materials Eng., Illinois Institute of Technology [IIT].

[10] Dr. Claudia J. Rawn, Joint Faculty, MSE, UT.

[11] Dr. John R. Ray, Professor, Dept. of Education, UT.

[12] Dr. Calvin Tszeng, Assistant Professor, Mechanical, Materials and Aerospace Eng., IIT.

[13] Dr. Ersan Ustundag, Assistant Professor, Materials Science, California Institute of Technology.

[14] Dr. Robert A. Winholtz, Associate Professor, Mechanical and Aerospace Eng., UMC.

<FACULTY PARTICIPANTS>

Canada

[15] Dr. Warren J. Poole, Associate Professor, Metals & Materials Eng., U. British Columbia, Canada.

Europe

[16] Dr. Lyndon Edwards, Professor, Materials Eng., Open Univ., UK.

[17] Dr. Alain Lodini, Professor, Mechanical Engineering, Reims Univ., France.

[18] Dr. Hans Priesmeyer, Professor, Institute of Exp. and Applied Physics, Kiel Univ., Germany.

[19] Dr. Anke R. Pyzalla, Professor, MSE, Technical Univ. Berlin, Germany.

[20] Dr. Walter Reimers, Professor, MSE, Technical Univ. Berlin, Germany.

[21] Dr. Philip J. Withers, Professor, Manchester Materials Science Center, Manchester Univ., UK.

Asia

[22] Dr. Takao Hanabusa, Professor, Dept. of Engineering, Tokushima Univ., Japan.

[23] Dr. Akihisa Inoue, Professor, MSE, Tohoku Univ.; and Director of Materials Res. Institute, Japan.

[24] Dr. Keisuke Tanaka, Professor, Dept. of Engineering, Nagoya Univ., Japan.

[25] Dr. Ke-Wei Xu, Professor and Dean of College of Eng., Xi'an Jiao Tong Univ., China.

<GOVERNMENT PARTICIPANTS FROM THE NEUTRON SCATTERING FACILITIES>

US

[26] Dr. Mark Bourke, Team Leader, Los Alamos Neutron Science Center [LANSCE], Los Alamos National Laboratory [LANL].

[27] Dr. Camden R. Hubbard, Group Leader, High Temperature Materials Laboratory [HTML], Oak Ridge National Laboratory [ORNL].

[28] Dr. Judy Pang, Staff Member, Metals and Ceramics Division, ORNL.

[29] Dr. Andrew Payzant, Research Staff, Metals and Ceramics Division, ORNL.

[30] Dr. Stephen Spooner, Research Staff, High Flux Isotope Reactor [HFIR], ORNL.

[31] Dr. Xun-Li Wang, Research Staff, Spallation Neutron Source [SNS], ORNL.

<GOVERNMENT PARTICIPANTS FROM THE NEUTRON SCATTERING FACILITIES>

Canada

[32] Dr. Ronald Rogge, National Research Council [NRC], Chalk River, Ontario, Canada.

Europe

[33] Dr. Mark Daymond, Group Leader, ISIS Facility, Rutherford Appleton Laboratory, UK.

Asia

[34] Dr. Yong Nam Choi, Staff Member, HANARO, Korea Atomic Energy Institute [KAERI], Korea.

[35] Dr. Yukio Morii, Group Leader, Japan Atomic Energy Research Institute [JAERI]; and Japanese Spallation Neutron Source [J-SNS], Japan.

[36] Dr. Wei Hua Wang, Group Leader, Institute of Physics, Chinese Academy of Science, China.

<US INDUSTRIAL PARTICIPANTS>

[37] Dr. Bob Binoniemi, Senior Metallurgist, DANA Corporation.

[38] Dr. Al Borges, Chief Metallurgist, ALCOA Extrusion Development Factory.

[39] Mr. Jose Aurrecoechea, Group Manager, Materials Technology, Solar Turbines, Inc.

[40] Dr. Arvid Casler, Senior Metallurgist, Federal-Mogul.

[41] Dr. Melvin R. Jackson, Corporate Fellow, Corporate R & D, General Electric Company.

[42] Dr. Dwaine L. Klarstrom, Director of R & D, Haynes International, Inc.

[43] Dr. Ismail C. Noyan, Materials & Processing Sciences, IBM T.J. Watson Research Center.

[44] Dr. Krishnan K. Sankaran, Fellow and Manager, Phantom Works, Boeing Company.

[45] Mr. Scott Thompson, Senior Engineer, Solar Turbines, Inc.

<ADMINISTRATIVE AND MANAGERIAL PARTICIPANTS>

[46] Dr. Tom M. Holden, Northern Stress Technologies [NST], Canada.

[47] Dr. Linda L. Horton, Associate Division Director, Metals and Ceramics Division, ORNL.

[48] Dr. Paul Lisowski, Director, LANSCE, LANL. [Support Letter]

[49] Dr. Lee Magid, Acting Director, Joint Institute for Neutron Sciences [JINS], UT. [Support Letter]

[50] Dr. Thomas E. Mason, Director, SNS, ORNL. [Support Letter]

[51] Dr. Arvid Pasto, Director, HTML, ORNL. [Support Letter]

[52] Dr. Andrew Taylor, Director, ISIS, Rutherford Appleton Laboratory, UK. [Support Letter]

[53] Dr. Fred D. Tompkins, Dean, College of Engineering [COE], UT. [Support Letter]

[54] Dr. Julia R. Weertman, Professor, MSE, Northwestern Univ.

EDUCATION AND TRAINING

- **ANSWER Faculty**

  The College of Engineering at the University of Tennessee (UT) is committed to open two or three new faculty positions.

- **ANSWER Fellows**

  A total of eight graduate student fellowships for the participating universities except UT, and four research assistants and one postdoctoral fellowship at UT will be provided.

EDUCATION AND TRAINING (Cont'd)

- **ANSWER Fellows** ***will benefit from the opportunities to conduct research in collaboration with world-class scientists at a number of national and international institutes.***

EDUCATION AND TRAINING (Cont'd)

- **ANSWER Courses:**

  Three neutron-diffraction courses for both undergraduate and graduate students.

1. ***Neutron Diffraction I – Fundamentals;***
2. ***Neutron Diffraction II – Applications;***
3. ***Graduate Seminar in Neutron-Diffraction Materials Research.***

EDUCATION AND TRAINING (Cont'd)

- **ANSWER Outreach Efforts Include:**
  1. K-12 science education;
  2. Minority outreach;
  3. Public awareness.
- ***Innovative recruitment and retention activities will be specially designed.***

INTERNATIONAL EXCHANGE PROGRAM

- **Objectives of the Exchange Program:**

1. Facilitate international cooperation in graduate research projects;

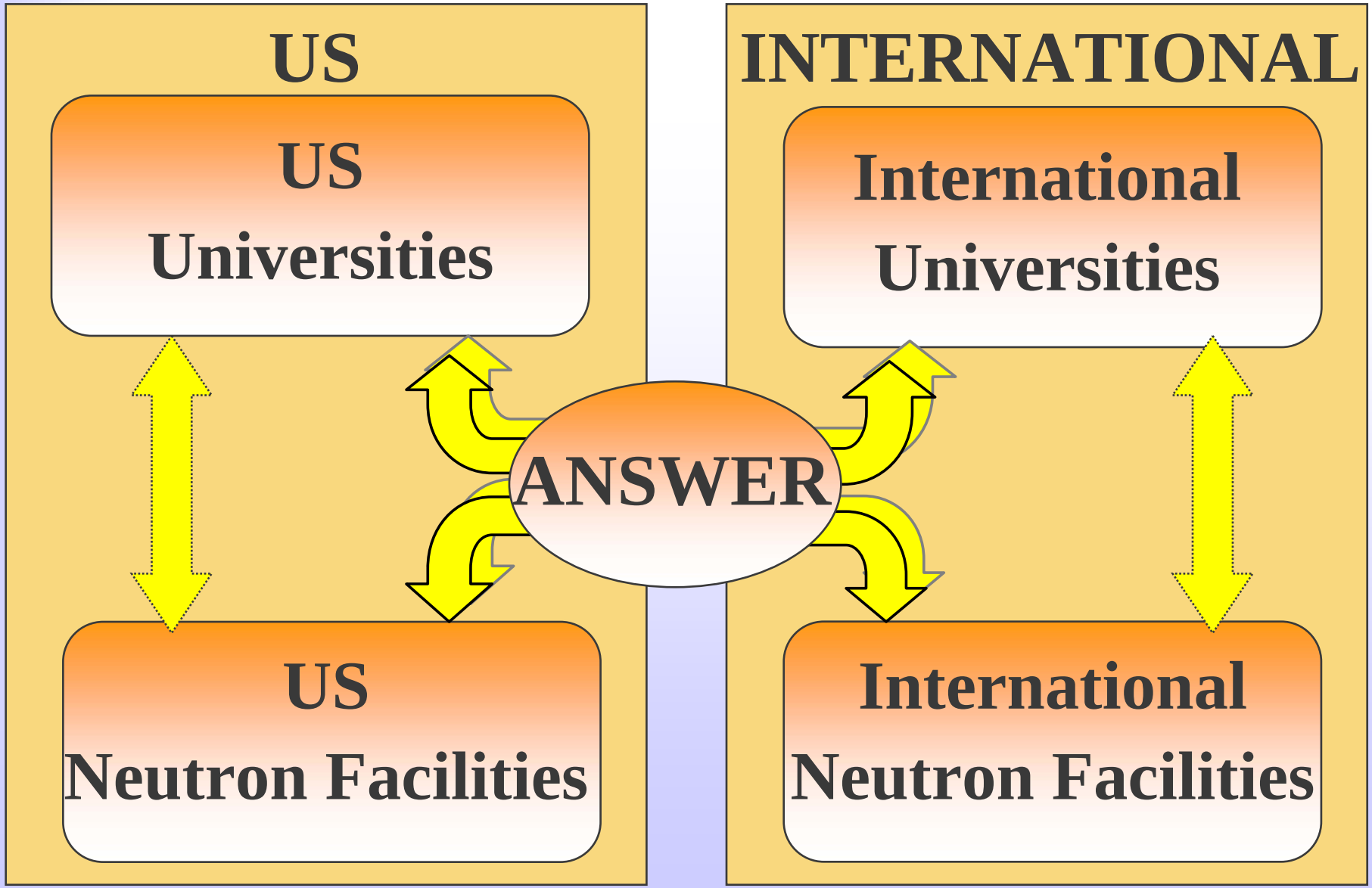
2. Foster access to international neutron facilities;

3. Attend international conferences and summer schools;

INTERNATIONAL EXCHANGE PROGRAM (Cont'd)

4. *Bring in well-trained postdoctoral scholars;*
5. *Advance neutron-scattering instrument development technologies;*
6. *Facilitate short-term study groups.*

INTERNATIONAL COLLABORATION



List of Confirmed International Participants and Their Expertise

Phase 1 [2003]: Canada and UK

T. Holden [NST]: Strain measurements; Polycrystalline deformation; Analytical modeling.
W. Poole [U. British Columbia]: Strain measurements.
R. Rogge [Chalk River]: Applied neutron diffraction techniques; Stress measurements.
M. Daymond [ISIS]: ENGIN-X instrument; *In-situ* studies on deformation mechanisms; Modeling.
L. Edwards [Open U.]: Fracture mechanics, Residual stresses in welds and large components.
P. Withers [Manchester U.]: UK neutron consortium; Composite mechanics; Residual stress.

Phase 2 [2004]: France, Germany, and Japan

A. Lodini [Reims U.]: Stress evaluation; Mechanical behavior characterization using diffraction.
H. Priesmeyer [Kiel U.]: *In-situ* deformation characterization of intermetallic alloys; FEM.
A. Pyzalla [Tech. Univ. Berlin]: Surface integrity; Residual stress in large components.
W. Reimers [Tech. Univ. Berlin]: Phase, texture, and residual stress analyses using neutrons.
T. Hanabusa [Tokushima Univ.]: Residual stress measurement; Quenching, casting, peening effects.
A. Inoue [Tohoku Univ.]: Synthesis and characterization of bulk metallic glasses.
Y. Morii [JAERI and J-SNS]: RESA diffractometer; Residual stress measurements; Japanese SNS.
K. Tanaka [Nagoya Univ.]: Fatigue of ultra-fine grained materials; Life predictions.

Phase 3 [2005]: China and Korea

W.H. Wang [C-SNS]: Physical properties of metastable phase under high pressure & low temperature.
K. Xu [Xi'an Jiao Tong Univ.]: Deformation mechanisms; Stress measurements.
Y. Choi [KAERI]: High Resolution Powder Diffractometer; Residual stress measurements.

RESEARCH OPPORTUNITIES

Neutron diffraction is a powerful tool for characterizing advanced materials with complex microstructures:

1. ***Neutrons penetrate most engineering materials three to four orders of magnitude deeper than conventional x-rays [cm vs. μm] and allow nondestructive bulk characterization.***
2. ***Neutrons provide structural information at the atomic level from individual phases and crystal planes, which is invaluable for probing multi-phase and multi-scale materials.***

Research Areas

Thrust-Area 1:

In-Situ Studies of Mechanical Behavior

Thrust-Area 2:

Real-Time Measurements of Internal Stresses

Thrust-Area 3:

In-Situ Studies of Microstructures

Thrust-Area 4:

Theoretical Modeling

PARTNERSHIPS

- **Joint Institute for Neutron Sciences [JINS];**
- **State of Tennessee;**
- **US DOE Neutron User Facilities;**
- **Industrial Internship;**
- **European Neutron-Scattering Consortia:**
  Neutron and Synchrotron Strain Scanning Network [NSSSN] in UK;
  Training Industry in Neutron Strain Scanning [TRAINSS] by European Union.

Symposium and Neutron School

SYMPOSIUM

- American Conference on "Neutron Scattering" [ACNS];
- TMS Annual Meeting

NEUTRON SCHOOL

- Annual International Summer School on "Application of Neutron Diffraction in Mechanical Behavior Studies".

INTERNET RESOURCES

- **Novel tele-research and communication;**
- **Web-based experiment simulation, instructional materials, and a searchable database.**

ANSWER WORKSHOP

- Identifying areas of important and innovative research for joint research programs;
- Progress reports on the cooperative research projects by senior members;
- Progress reports by ANSWER Fellows, and evaluation;
- Selection of new Fellows;
- Planning of the Exchange Program for the following year;
- Preparation and scheduling of neutron beam-time proposal writing on the collaborative research projects for the upcoming year.

SUMMARY OF KEY MILESTONES

Year 1 [2003]

1st Workshop [UT], Knoxville, Tennessee, November 16-20, 2003; Develop a domestic consortium; Develop a partnership with JINS; Network with Canada and UK; Develop a partnership with NSSSN; Recruit a senior level faculty for neutron science at UT; Start Fellowship and Internship Programs.

Year 2 [2004]

2nd ACNS Conference; 2nd Workshop [ACNS site]; 1st Neutron School [ACNS site]; Develop partnerships with France, Germany, and Japan; Start the Exchange Program; Recruit a junior-level faculty for neutron science at UT; Start the Neutron-Diffraction Course I [Fall].

SUMMARY OF KEY MILESTONES (Cont'd)

Year 3 [2005]

1st TMS Symposium; 3rd Workshop [TMS site]; 2nd Neutron School [ORNL]; Develop partnerships with Australia, China, and Korea; Form a global network; Attain an office and a support staff in JINS [SNS] building; Recruit a junior-level faculty for neutron science at UT; Start the Neutron-Diffraction Course II [Spring]; Start the Graduate-Seminar Course.

SUMMARY OF KEY MILESTONES (Cont'd)

Year 4 [2006]

3rd ACNS Conference; 4th Workshop [ACNS site]; 3rd Neutron School [ACNS site]; Fully operational global network; Commissioning of SNS; Commissioning of ANSWER virtual internet-based Institute capable of tele-research and communication.

Year 5 [2007]

2nd TMS Symposium; 5th Workshop [TMS site]; 4th Neutron School [ORNL]; Apply for the State of Tennessee funding to develop a Center of Excellence in partnership with JINS and SNS.

NSF IMI Program: Advanced Neutron Scattering Network for Education and Research

Director: Prof. Peter Liaw, Co-Director: Prof. Hahn Choo

Program-Assessment Committee

Prof. Julia Weertman [Chair], NU

Dr. Linda Horton, ORNL

Dr. Melvin Jackson, GE

Development and Implementation of Performance-Assessment Tools

Prof. John Ray, UT

Education Program

Dean Fred Tompkins, UT

Faculty Recruitment

Prof. Ray Buchanan, UT

Prof. Peter Liaw, UT

ANSWER Fellowship

Prof. Peter Liaw, UT

Prof. Aaron Krawitz, UMC

Prof. Hahn Choo, UT

Prof. David Dunand, NU

Prof. Ersan Ustundag, Caltech

New Course Development

Prof. Claudia Rawn, UT

Prof. Hahn Choo, UT

Prof. Charlie Brooks, UT

Outreach Program

Prof. Claudia Rawn, UT

Prof. Charlie Brooks, UT

Mr. James Pippin, UT

Prof. Ray Buchanan, UT

Service Program

Prof. Lee Magid, UT/JINS

Exchange Program

- Dr. Mark Bourke, LANL
- Prof. Phil Withers, Manchester U.
- Dr. Mark Daymond, ISIS
- Dr. Xun-Li Wang, ORNL

Workshop and Symposium

- Prof. Peter Liaw, UT
- Prof. Hahn Choo, UT
- Dr. Camden Hubbard, ORNL
- Dr. Xun-Li Wang, ORNL

Neutron School

- Prof. Andy Winholtz, UM
- Dr. Mark Bourke, LANL
- Dr. Camden Hubbard, ORNL

Internet Resources

- Prof. Hahn Choo, UT
- Prof. Lyndon Edwards, Open U.
- Dr. Camden Hubbard, ORNL
- Dr. Xun-Li Wang, ORNL

Research Programs

Dr. Tom Holden, NST

Thrust-Area 1 Leaders

- **Prof. Peter Liaw, UT**
- **Dr. Mark Bourke, LANL**

Thrust-Area 2 Leaders

- **Prof. Hahn Choo, UT**
- **Dr. Camden Hubbard, ORNL**

Thrust-Area 3 Leaders

- **Prof. Takeshi Egami,**

  UT-UPenn
- **Prof. Claudia Rawn, UT**

Thrust-Area 4 Leaders

- **Dr. Bjorn Clausen, Caltech**
- **Prof. Calvin Tszeng, IIT**

National-Lab Internship

- Dr. Mark Bourke, LANL
- Dr. Camden Hubbard, ORNL
- Dr. Judy Pang, ORNL

International Collaboration

- Prof. Peter Liaw, UT
- Prof. Phil Withers, Manchester U.
- Dr. Ron Rogge, NRC
- Dr. Yukio Morii, JAERI

Industry Internship

- Prof. Philip Nash, IIT
- Prof. Peter Liaw, UT
- Dr. Arvid Pasto, ORNL
- Dr. Dwaine Klarstrom, Haynes
- Dr. I. Cevdet Noyan, IBM

Partnership Development

- Prof. Peter Liaw, UT
- Dr. Steve Spooner, ORNL

Conclusions

- ***The NSF-IMI Program includes participants from US and international universities, industries, and government.***
- ***The education and training program includes ANSWER faculty, fellows, courses, and outreach efforts.***

Conclusions (Cont'd)

- ***The international exchange program and collaboration will be established.***

- ***Research-thrust areas include in-situ studies of mechanical behavior, real-time measurements of internal stresses, in-situ studies of microstructures, and theoretical modeling.***

Conclusions (Cont'd)

- ***The symposium, workshop, and neutron school will be planned. The first workshop will be at Knoxville, Tennessee, November 16-20, 2003.***
- ***There are well-defined outlines for the key milestones from 2003 to 2007.***
- ***The organization and management plan of the NSF-IMI Program will be established.***


THANK YOU!